ISSN 2348 – 8034
Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

EVALUATION OF TENSILE STRENGTH OF DRIED BANANA STEM AND ITS STRESS ANALYSIS ON A BOWL GEOMETRY USING ANSYS SOFTWARE

Harshit Dixit[*1], Ram Manohar Singh Yadav[2] & Aditya Kumar[3]
[*1,2&3]Axis Institute of Technology and Management, Kanpur Dr APJ Abdul Kalam Technical University, Lucknow

ABSTRACT

Banana plants are found in tropical regions and other places irrespective of the season. Until now the use of the banana leaf has been seen but other parts of the banana tree such as stem received very less attention. The plastic and thermocol disposals used today are causing environmental hazards. These disposals can be replaced by disposals made of the banana stem which is a waste material after the tree has given its fruits. This work aims to find out the temperature and soaking time required for the banana stem to get 80% dryness. For these different samples were taken from the banana stem and heated at a different temperature for the different time interval. The tests were conducted at 60°C, 70°C, 80°C, 90°C and 100°C. The soaking time interval for each temperature was 10, 15, 20, 25, 30 and 45 minutes. The best dryness was obtained at 100°C for 45minutes. The tensile test sample was prepared and tested on INSTRON 1195 in triplication. The average tensile strength obtained was 25.818 MPa. A bowl was modelled and analyzed using solid works & ANSYS software. Taking the properties value obtained from the UTM test as the required engineering data for the analysis the pressure was applied on the bowl geometry. The value of the pressure was varied until the equivalent stress obtained from the analysis reached approximately to 25.818 MPa. It was found that the maximum pressure that reached the stress value of 25.818 MPa was 0.45MPa. Thus a load which creates the pressure of 0.45MPa can be reasonably sustained by the bowl and thus can replace the bowl made of plastic or thermocol thus preventing the environment.

Keywords: *Soaking time, Tensile strength, INSTRON, Dryness, ANSYS.*

I. INTRODUCTION

Today a lot of disposal components made of plastics are been widely used which are non- biodegradable and pose environmental hazards. In order to eliminate these hazards, natural fibres are being extensively used. Leaves and fibres of different plants have been tested and researchers are trying to get the best suited fibrous material obtained from natural resources to meet the requirement. Many researchers are focussing on developing the composites of the natural fibres along with the chemical treatment to meet the demand but they suffer from the disadvantage of cost-effectiveness, loss of strength and the medical requisites.

The present paper deals with the making of disposals using banana stem. Since the ancient times, banana leaves have been used as plates for serving the food and the other items. Banana tree has been considered as the sacred tree in Hindu mythology. Banana tree cultivation is done on the large scale in India. The tree after giving its fruits is cut and the remaining is the waste. The objective of the paper is to present the maximum utilization of the tree after it has given its fruits. This will be in the benefit of the farmers as they can sell the stem to the manufacturers for whom it can act as the raw material.

II. METHODOLOGY

Preparation of test specimen

A different layer of the banana stem was taken and soaked in the running tap water and brushed to remove any dirt. After the proper washing of the layer of the banana stem, they were kept in dry air for getting it to be dried. Then the tapes were wound on the banana layers from the bottom surface to the upper surface of the layer. It was then followed by pressing them tightly and heating the samples in the hot air oven to remove the moisture for moulding the banana stem into a bowl shape.

Heating at a constant temperature of 60℃

Firstly the weights of all the samples were taken using electronic weight balance. The first constant temperature selected was 60°C. The different samples were taken and kept in the hot air at a constant temperature of 60°C for the duration of 10 minutes. After heating for the time duration of 10 min. The samples were weighted again and the percentage loss of the moisture was being calculated using the unitary method. After this, the sample was heated for 15minutes, 20 minutes, 25 minutes and 30 minutes respectively. After each duration, the weight of the sample was measured and percentage loss of the moisture (dryness fraction) as calculated and all the results were then tabulated (table -1).

Heating at a constant temperature of 70℃, 80℃ and 90℃

The second set of the sample was taken and weighted at the green stage. The second constant temperature taken was 70°C and the samples were heated at this temperature for the duration of 10minutes, 15minutes, 20minutes, 25 minutes and 30 minutes. After each duration, the heated samples were weighted and the percentage loss of moisture was calculated (dryness fraction) and tabulated (table-2). The same procedure was repeated for the **third** and the **fourth** set of samples by heating at a constant temperature of **80**°C and **90**°C respectively and the data obtained were tabulated (table 3,table-4).

Heating at a constant temperature of 100℃

The fourth set of the sample was taken and weighted at the green stage. The fourth constant temperature taken was 100°C. And the sample was heated at this temperature for the duration of 10minutes, 15minutes, 20minutes, 25 minutes, 30 minutes and 45minutes. After each duration, the heated samples were weighted and the percentage loss of moisture was calculated (dryness fraction) and tabulated (table-5).

Preparation of Test specimen for UTM testing

From the sample obtained by heating at **100**℃ for 45minutes the dog boned sample was cut from it (figure 1, figure 2) (Buku A. & Sahari N.G) [5]. In order to find the tensile strength of the dried banana stem, the tensile test was conducted on the UTM machine (INSTRON 1195). And the tensile strength was thus evaluated.

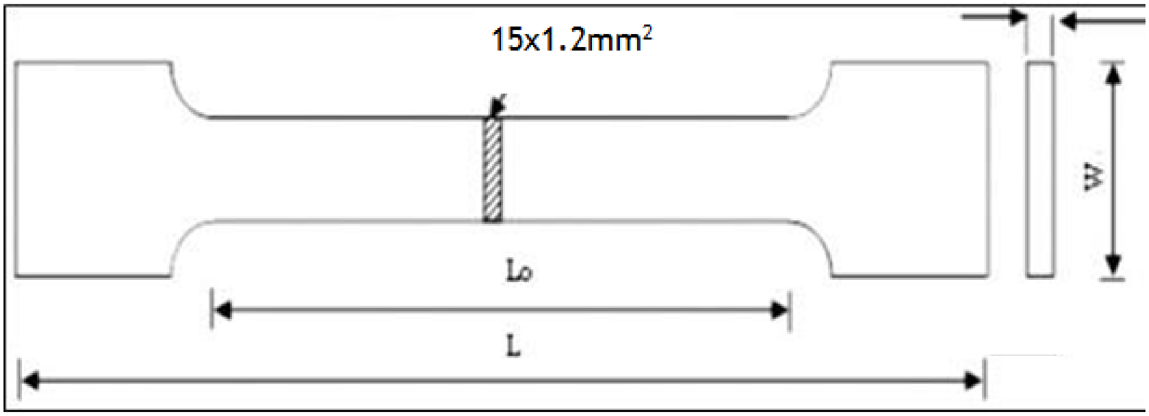
Making of the small bowl from the dried banana stem

Using a die punch assembly (press machine) a small cup-shaped part was formed from the dried banana stem. Some temperature was given at the later stage for the proper moulding(figure-4).

Stress Analysis of bowl-shaped part using ANSYS software

The model of the bowl-shaped part was modelled in the Solid Works and its analysis was conducted using ANSYS software.

ISSN 2348 – 8034
Impact Factor- 5.070



Where
W= Specimen width (25 mm)
L = Total length of specimen (150 mm) Lo = Gauge length (80 mm)
h = Specimen thickness (1.2 mm)

Figure 1: Dimension of the tensile test specimen

Figure 2: Original Specimen for testing using UTM

Figure 3: Fractured specimen after UTM testing

Figure 4: A bowl made from die punch assembly

ISSN 2348 – 8034
Impact Factor- 5.070

III. MECHANICAL TESTING ON UNIVERSAL TESTING MACHINE

Figure 5(a) Front View of INSTRON 1195

Figure 5(b) Close View of INSTRON 1195

Type of Machine	Screw-driven
Maximum Capacity	100kN
Minimum Load can be tested	1gm
Types of Test can be performed	Tensile, Compression, 3-pt bend,4-pt bend, Loading-Unloading and Oil dip tensile(up to 400℃in silicon oil)
Types of the materials can be tested	Metallic, plastic, Ceramic, Rubber and fiber
Available Load cells	Tensile or Compression : 200N,800N ,2kN,100kN Tensile only 50gm Compression only : 50kg ,2kg
Types of the sample can be tested	Round, Flat , Sheet, Wire , Rod or Tubular
Crosshead Speed (Strain Rate)	Max – 40mm/min Min – 0.005mm/min
Crosshead Displacement	Max – 700mm
Type of test control	Stroke, Load and strain

Type of Extensometers	GL 25mm (travel 2.5mm), GL25mm (travel 25mm),COD -10mm and Transverse – 12.5mm

Figure 5: Universal Testing Machine

IV. RESULTS AND DISCUSSIONS

Result obtained from heating at a constant temperature of 60℃

Figure 6 shows the graph plotted between time and the dryness fraction for the data of table1. From the graph, it is seen that the rate of moisture removal increases linearly as the time duration for heating is increased. Though the dryness fraction increased yet it is not sufficient for the moulding of the banana plant. Hence it is required that the temperature of the heating should be increased.

Result obtained from heating at a constant temperature of 70℃

From the experiment, it has been observed that the rate of removal of moisture required is not achieved when heated at the constant temperature of 60℃. Therefore the next experiment was conducted at the constant temperature of 70℃. Figure 7shows the graph plotted between time and the dryness fraction for the data of table-2. From the graph, it is seen that the rate of moisture removal increases linearly as the time duration for heating is increased. Though the dryness fraction increased yet it is not sufficient for the moulding of the banana plant. Hence it is required that the temperature of the heating should be increased.

Result obtained from heating at a constant temperature of 80℃

Figure 8 shows the graph plotted between time and the dryness fraction for the data of table3. From the graph, it is seen that the rate of moisture removal increases linearly as the time duration for heating is increased. Though the dryness fraction increased yet it is not sufficient for the moulding of the banana plant. Hence it is required that the temperature of the heating should be increased.

Result obtained from heating at a constant temperature of 90℃and100℃

From the experiment, it has been observed that the rate of removal of moisture required is not achieved even when heated at the constant temperature of 80℃. Therefore the next experiment was conducted at the constant temperature of 90℃. Here also the required dryness was not achieved and as a result, the next heating temperature chosen was 100℃. Figure 9 shows the graph plotted between time and the dryness fraction for the data of table

4. From the graph, it is seen that the rate of moisture removal increases linearly as the time duration for heating is increased. Figure 10 shows the graph plotted between time and the dryness fraction for the constant temperature of 100℃using data of table5.

Table 1: Tabulated data for a constant temperature of 60

Data at Constant temperature (60°C)					
Sr.No.	**Time (min)**	**l Weight (gm)**	**l weight (gm)**	**Change in weight (gm)**	**Dryness %**
1	10	40.68	38.26	2.42	5.95
2	15	37.68	34.81	2.87	7.62
3	20	32.76	29.92	2.84	8.67
4	25	32.08	28.45	3.63	11.32
5	30	31.1	27.32	3.78	12.15

ISSN 2348 – 8034
Impact Factor- 5.070

Data at Constant temperature (70°C)					
Sr. No.	**Time (min)**	**Initial Weight (gm)**	**Final weight (gm)**	**Change in weight (gm)**	**Dryness %**
1	10	38.25	34.49	3.76	9.83
2	15	40.42	36.18	4.24	10.49
3	20	40.64	34.65	5.99	14.74
4	25	40.42	34.39	6.03	14.92
5	30	40.79	32.74	8.05	19.74

Table -2 Tabulated data for a constant temperature of 70℃

Data at Constant temperature (80°C)					
Sr. No.	**Time (min)**	**Initial Weight (gm)**	**Final weight (gm)**	**Change in weight (gm)**	**Dryness %**
1	10	35.83	32.18	3.65	10.19
2	15	35.66	30.9	4.76	13.35
3	20	35.92	30.29	5.63	15.67
4	25	36.21	28.67	7.54	20.82
5	30	35.74	27.66	8.08	22.61

Table 3: Tabulated data for a constant temperature of 80℃

Data at Constant temperature (90°C)					
Sr. No.	**Time (min)**	**Initial Weight (gm)**	**Final weight (gm)**	**Change in weight (gm)**	**Dryness %**
1	10	31.47	26.53	4.94	15.70
2	15	32.44	26.17	6.27	19.33
3	20	32.53	24.88	7.65	23.52
4	25	32.92	24.02	8.9	27.04
5	30	32.89	21.63	11.26	34.24

Table 4: Tabulated data for a constant temperature of 90℃

Data at Constant temperature (100°C)					
S.No.	Time (min)	l Weight (gm)	l weight (gm)	in weight (gm)	Dryness %
1	10	35.36	29.47	5.89	16.66
2	15	34.79	26.81	7.98	22.94
3	20	35.53	24.86	10.67	30.03

4	25	35.42	22.02	13.4	37.83
5	30	35.26	20.99	14.27	40.47
6	45	27.85	8.76	19.09	68.55
7	60	26.89	5.11	21.78	81.00

Table 5: Tabulated data for a constant temperature of 100

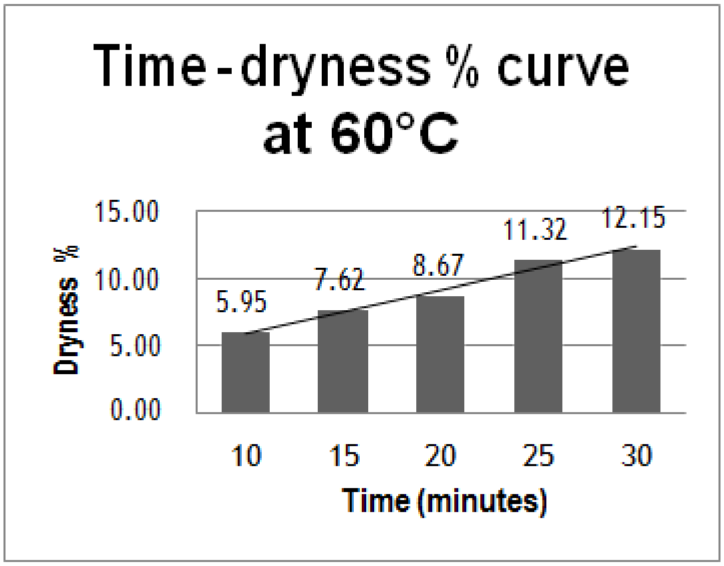


Figure 6: Time-dryness% curve at 60

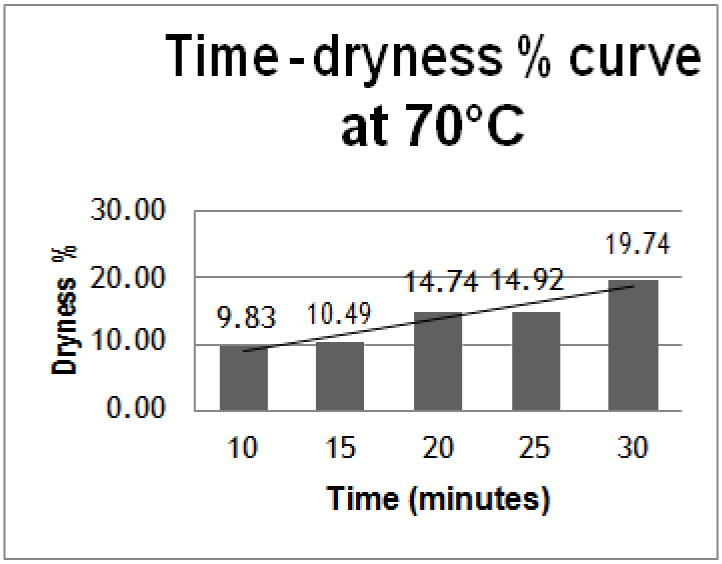


Figure 7: Time-dryness% curve at 70

ISSN 2348 – 8034
Impact Factor- 5.070

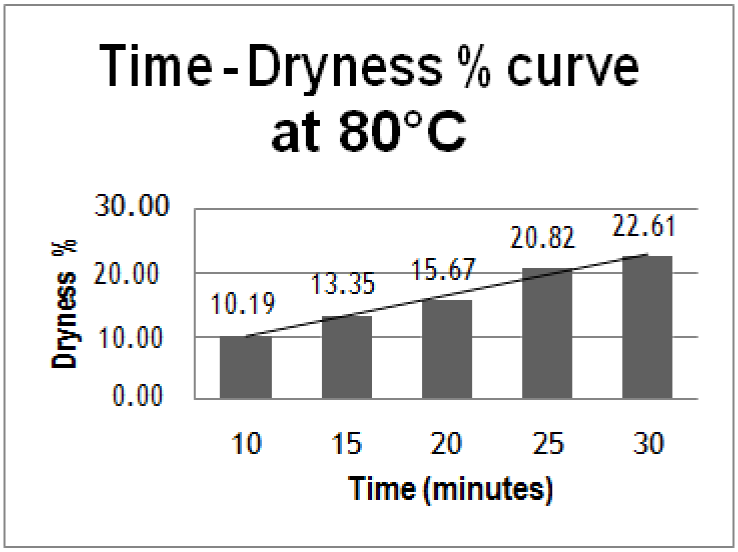


Figure 8: Time-dryness% curve at 80

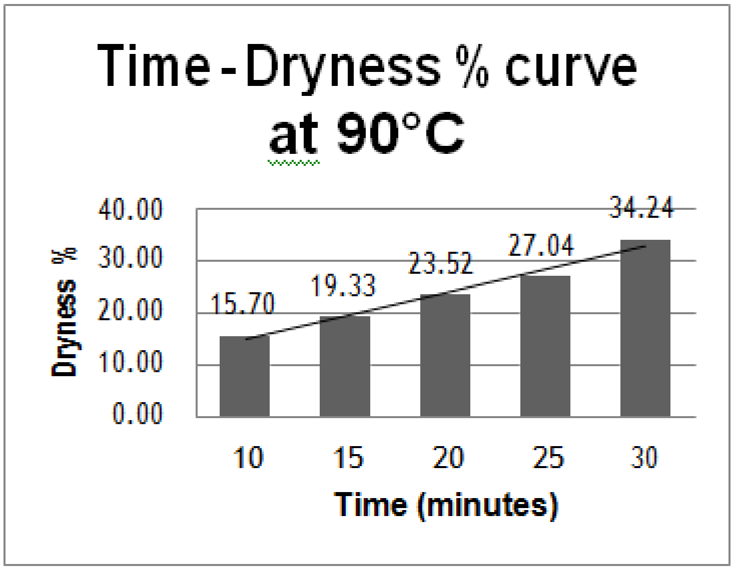


Figure 9: Time-dryness% curve at 90

ISSN 2348 – 8034
Impact Factor- 5.070

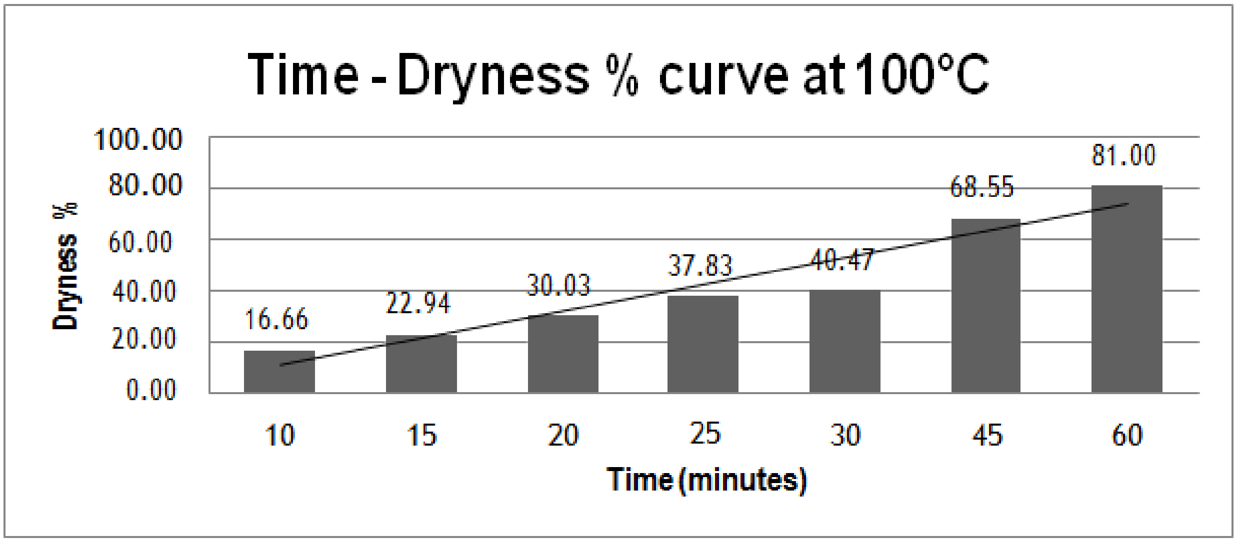


Figure 10: Time-dryness% curve at 100

Stress-Strain Curves Obtained From the Tensile Test

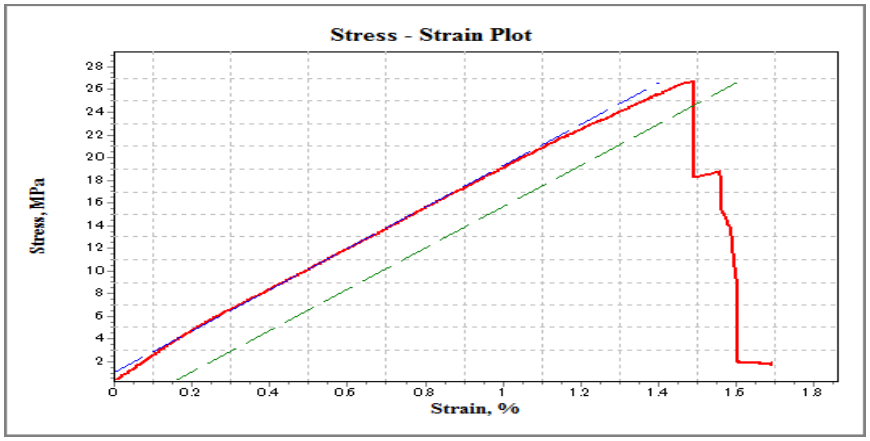


Figure 11: Stress-strain curve for sample 1

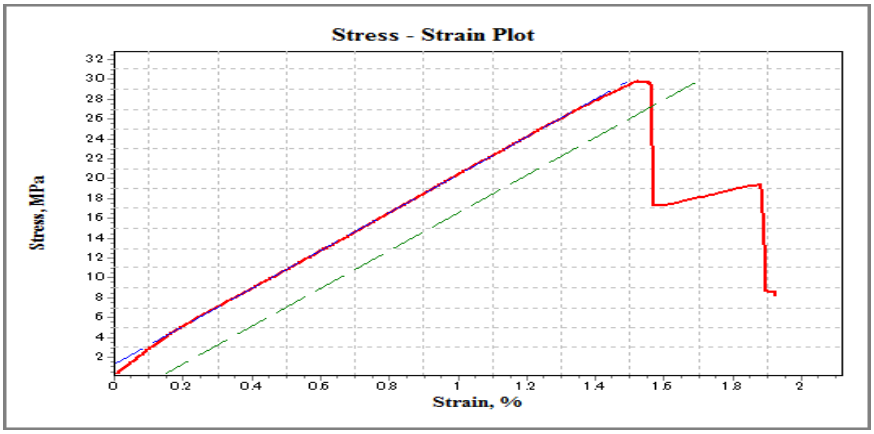


Figure 12: : Stress-strain curve for sample 2

ISSN 2348 – 8034
Impact Factor- 5.070

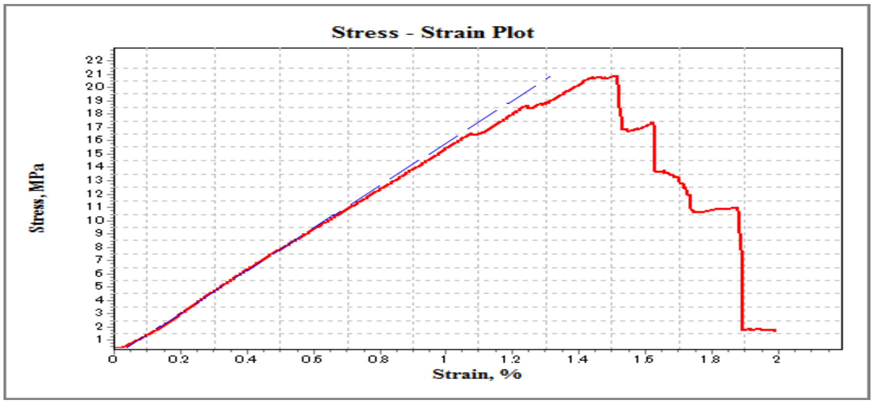


Figure 13: : Stress-strain curve for sample 3

Table 6: Combined Stress- strain result of the three samples

Combined Stress- strain result of the three samples				
Parameters	**Sample 1**	**Sample 2**	**Sample 3**	**Average**
Peak Stress (MPa)	26.684	29.848	20.922	25.818
Peak Load (kN)	0.747	0.836	0.594	0.72567
Yield Load (kN)	0.516	0.656	0.267	0.47967
Elongation at Break (Using Strain) (%)	1.692	1.925	1.992	1.86967

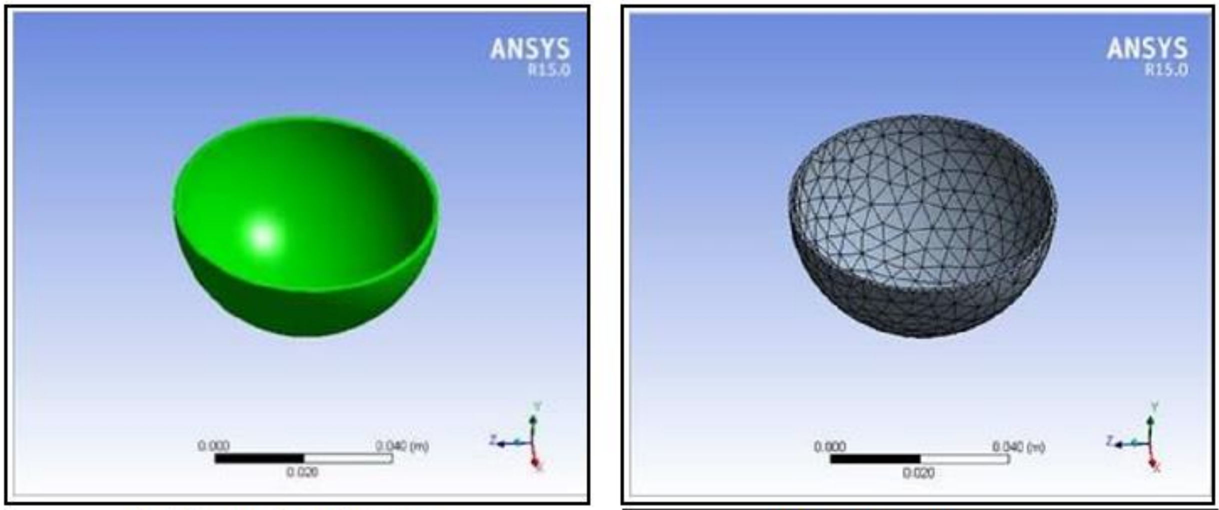
V. ANALYSIS USING ANSYS SOFTWARE

ANSYS is the usually preferred analysis software package because of its functionality. In this interface, you can apply forces, pressures, torques, etc on the models and see how the stresses develop. An innovative project schematic view ties together the entire simulation process, guiding the user through even complex design.

Meshing

Mesh generation is one of the most critical aspects of engineering simulation. Too many cells may result in long solver runs, and too few may lead to inaccurate results.

ISSN 2348 – 8034
Impact Factor- 5.070



(a): Importing of geometry **(b):** Meshing of geometry

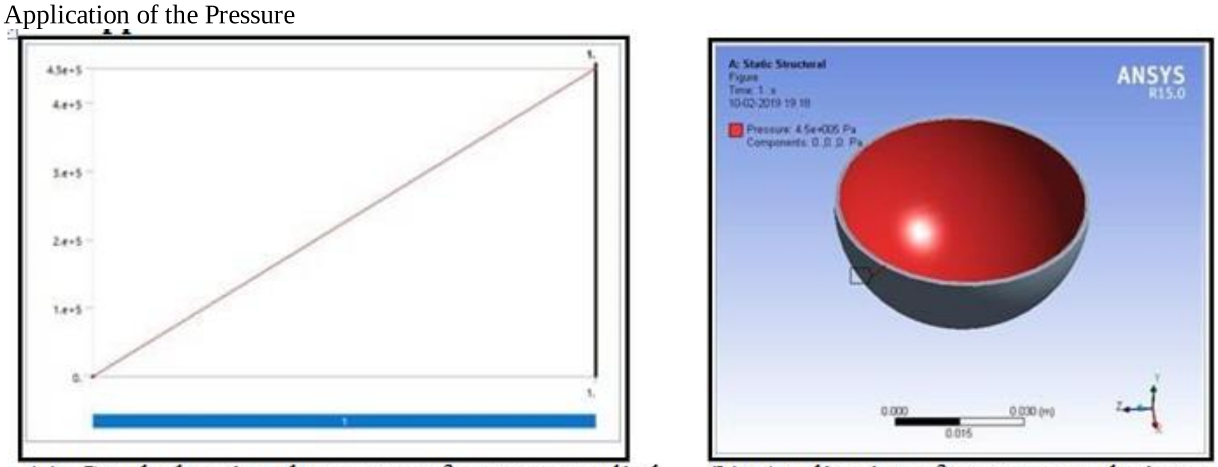
Figure 14

A bowl was made in the solid works and thereafter it was imported in the ANSYS software where new material was created and the properties of the banana stem obtained from UTM test were assigned to it. Figure 14(a) shows the result after importing of the bowl.

Figure 14(b) shows the meshing of the component which was done after importing and assigning the properties of the material. The dimension of the bowl are as follows :

Larger dia = 60mm   Inner dia = 59 mm   The thickness of the bowl = 1mm

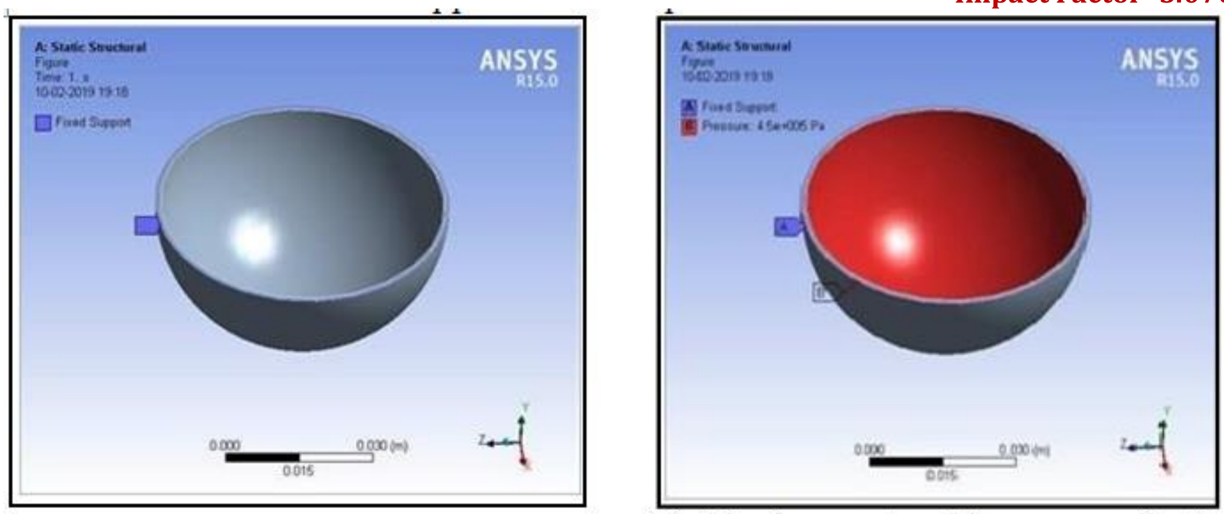
Application of the Pressure



(a): Graph showing the amount of pressure applied **(b):** Application of pressure on the internal surface of the bowl

Figure 15

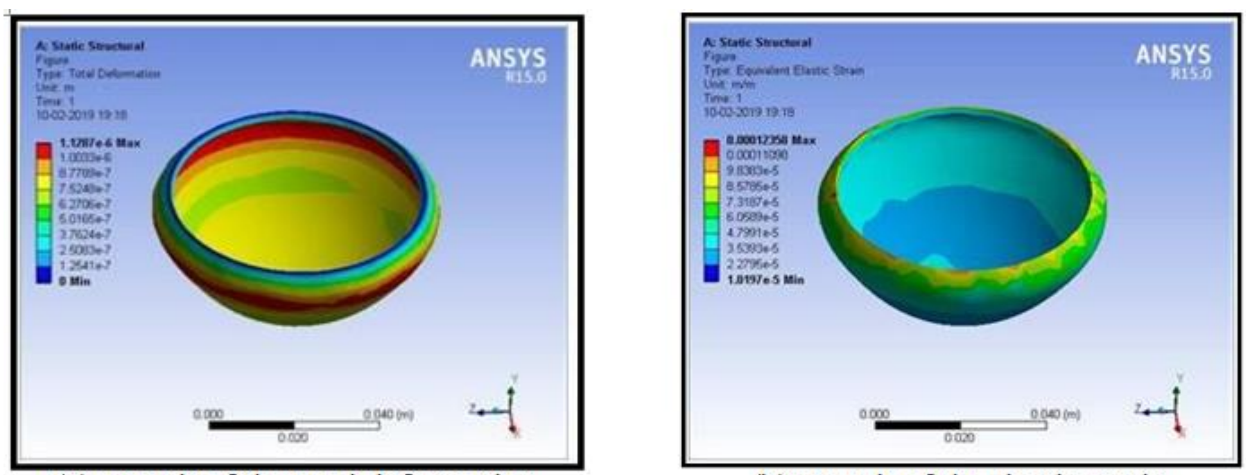
In order to check the maximum pressure that the bowl made from the dried banana stem can sustain, the pressure is applied. Figure 15(a) shows the graph obtained when the pressure was applied. The pressure increases linearly. Figure 15(b) shows the surface on which the pressure is applied. Since the food item will be loaded on the inner surface, therefore, the inner surface is selected for the application of the pressure.



(a) : Fixed Support application **(b):** Fixed support and Pressure application

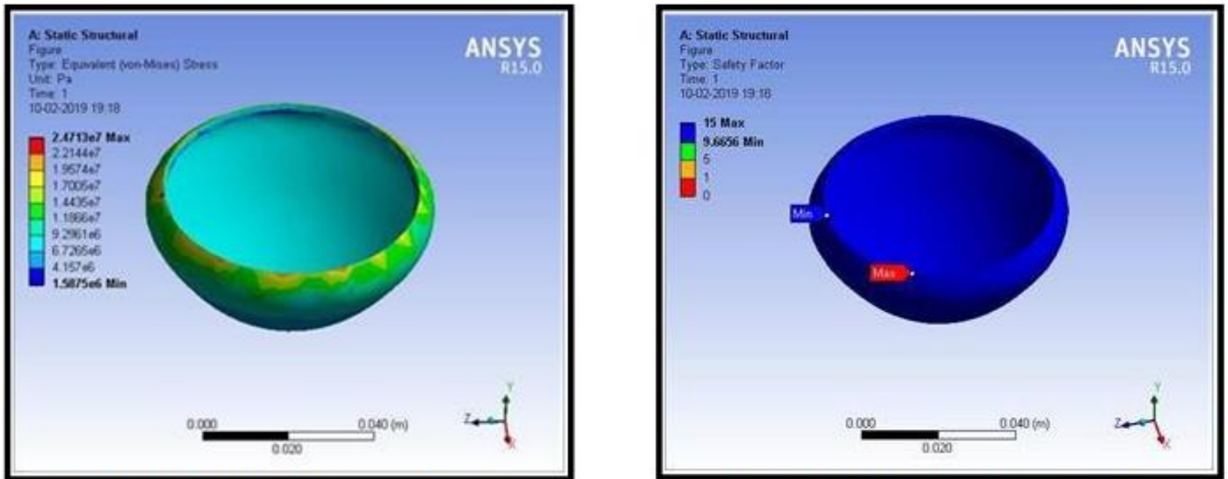
Figure 16

Figure 16(a) shows the selection of the fixed support. The edge is selected as the fixed support. Figure 16(b) shows the combined application of the pressure and the fixed support.



(a): Result of the total deformation (b): Result of the elastic strain

ISSN 2348 – 8034
Impact Factor- 5.070



(c) : Result of the equivalent stress (d) : Result of the Safety Factor

Figure 17

The result obtained by solving in the ANSYS software is shown in figure 17. The parameters on which the results were determined were total deformation(figure17,a), elastic strain (figure

17,b), equivalent stress(figure 17,c) and a factor of safety(figure 17,d). Figure 17 shows the distribution of the intensity of the parameter throughout the body of the component (bowl).

VI. CONCLUSION

From the present paper, it is thus seen that the banana stem can be reasonably used for the making of disposable if it is heated at a required temperature and proper soaking time. By doing this plastic disposable can be replaced which creates pollution. The dried banana stem has sufficient strength which can be seen from the UTM testing. The average tensile strength obtained was 25.818 MPa. A bowl was modelled in solid works & analyzed using ANSYS software. Taking the properties value obtained from the UTM test as the required engineering data the pressure that can be applied on the bowl geometry was determined. The value of the pressure was varied until the equivalent stress obtained from the analysis reached approximately to 25.818 MPa. It was found that the maximum pressure that reached the stress value of 25.818 MPa was 0.45MPa.Thus a load which creates the pressure of 0.45MPa can reasonably be sustained by the bowl and thus can replace the bowl made of plastic or thermocol thus preventing the environment. Therefore dried banana stem with the dryness of 80 to 90% can be used for making of the disposal.

REFERENCES

1. *Anirudhan, T. S., Senan, P., & Unnithan, M. R. (2007). Sorptive potential of a cationic exchange resin of carboxyl banana stem for mercury (II) from aqueous solutions. Separation and Purification Technology, 52(3), 512-519.*
2. *Baharin, A., Fattah, N. A., Bakar, A. A., & Ariff, Z. M. (2016). Production of laminated natural fibre board from banana tree wastes. Procedia Chemistry, 19, 999- 1006.*
3. *Baig, M. M. V., Mane, V. P., More, D. R., Shinde, L. P., & Baig, M. I. A. (2003).Utilization of banana agricultural waste: production of cellulases by soil fungi. Journal of environmental biology, 24(2), 173-176.*
4. *Bhatnagar, R., Gupta, G., & Yadav, S. (2015). A Review on Composition and Properties of Banana Fibers. Cellulose, 60, 65.*
5. *Buku A. & Sahari N.G (2017). Analysis of morphology and tensile strength of banana kepokfibres using a scanning electron micrograph (sem) and pull test equipment VOL. 12, NO. 3,*

6. Indira, K. N., Parameswaranpillai, J., & Thomas, S. (2013). Mechanical properties and failure topography of banana fiber PF macrocomposites fabricated by RTM and CM techniques. ISRN Polymer Science, 2013.
7. Ingale, S., Joshi, S. J., & Gupte, A. (2014). Production of bioethanol using agricultural waste: banana pseudo stem. Brazilian Journal of Microbiology, 45(3), 885-892.
8. Kalia, V. C., V. Sonakya, and N. Raizada. "Anaerobic digestion of banana stem waste." Bioresource Technology 73, no. 2 (2000): 191-193.
9. Krishna, C., & Chandrasekaran, M. (1996). Banana waste as substrate for α- amylase production by Bacillus subtilis (CBTK 106) under solid-state fermentation. Applied Microbiology and Biotechnology, 46(2), 106-111.
10. Maleque, M., Belal, F. Y., & Sapuan, S. M. (2007). Mechanical properties study of pseudo- stem banana fiber reinforced epoxy composite. The Arabian journal for science and engineering, 32(2B), 359-364.
11. Maleque, M., Belal, F. Y., & Sapuan, S. M. (2007). Mechanical properties study of pseudo- stem banana fiber reinforced epoxy composite. The Arabian journal for science and engineering, 32(2B), 359-364.
12. Mostafa, M., & Uddin, N. (2015). Effect of banana fibers on the compressive and flexural strength of compressed earth blocks. Buildings, 5(1), 282-296.
13. Namasivayam, C., and N. Kanchana. "Waste banana pith as adsorbent for color removal from wastewaters." Chemosphere25, no. 11 (1992): 1691-1705.
14. Namasivayam, C., Kanchana, N., & Yamuna, R. T. (1993). Waste banana pith as adsorbent for the removal of rhodamine-B from aqueous solutions. Waste Management, 13(1), 89-95.
15. Pappu, A., Patil, V., Jain, S., Mahindrakar, A., Haque, R., & Thakur, V. K. (2015).Advances in industrial prospective of cellulosic macromolecules enriched banana biofibre resources: A review. International journal of biological macromolecules, 79, 449-458.
16. Pothan, L. A., Thomas, S., & Neelakantan, N. R. (1997). Short banana fiber reinforced polyester composites: mechanical, failure and aging characteristics. Journal of Reinforced Plastics and Composites, 16(8), 744-765.
17. Prasad, A. V., Rao, K. M., & Nagasrinivasulu, G. (2009). Mechanical properties of banana empty fruit bunch fibre reinforced polyester composites.
18. Thakur, S., Shrivastava, B., Ingale, S., Kuhad, R. C., & Gupte, A. (2013). Degradation and selective ligninolysis of wheat straw and banana stem for an efficient bioethanol production using fungal and chemical pretreatment. 3 Biotech, 3(5), 365-372.
19. Waghmare, P. M., Bedmutha, P. G., & Sollapur, S. B. Review on Mechanical Properties of Banana Fiber Biocomposite.